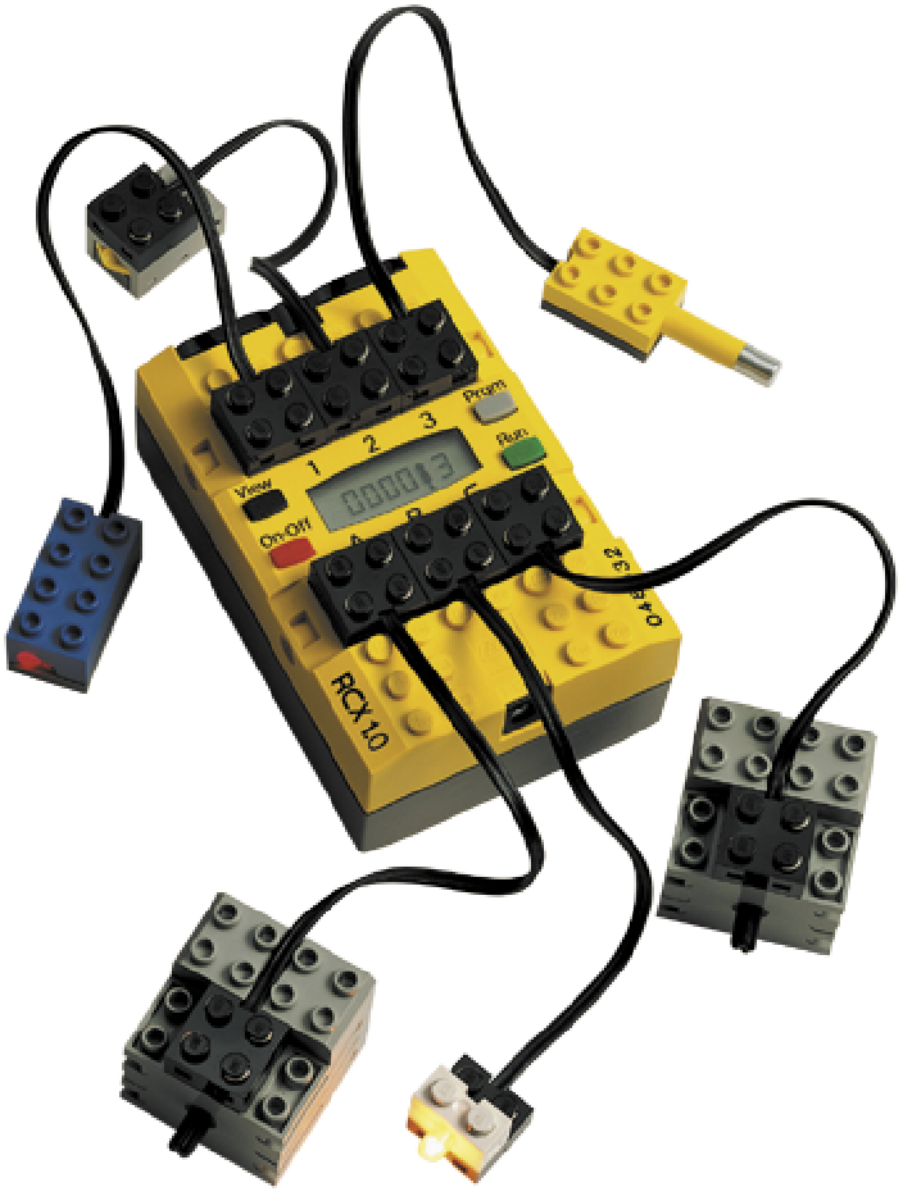
Quick Start Guide to computer control and robotics using LEGO® MINDSTORMS™ for Schools



www.LEGO.com/education/MINDSTORMS

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This guide is intended for all first time users of LEGO® MINDSTORMS™ for Schools and the ROBOLAB software (versions 2.0 or higher). It is a brief guide that will help you to install the software and try out some of the basic programming principles. It is intended as a brief introduction. You will need the ROBLAB User Guide to become fully conversant with the concept. The guide is based on functions within ROBOLAB 2.0.

We recommend that you carry out this program in two steps—the Pilot Course followed by the Inventor Course. Have fun! You will need either a RoboTechnology Set or Team Challenge Set to complete this course.

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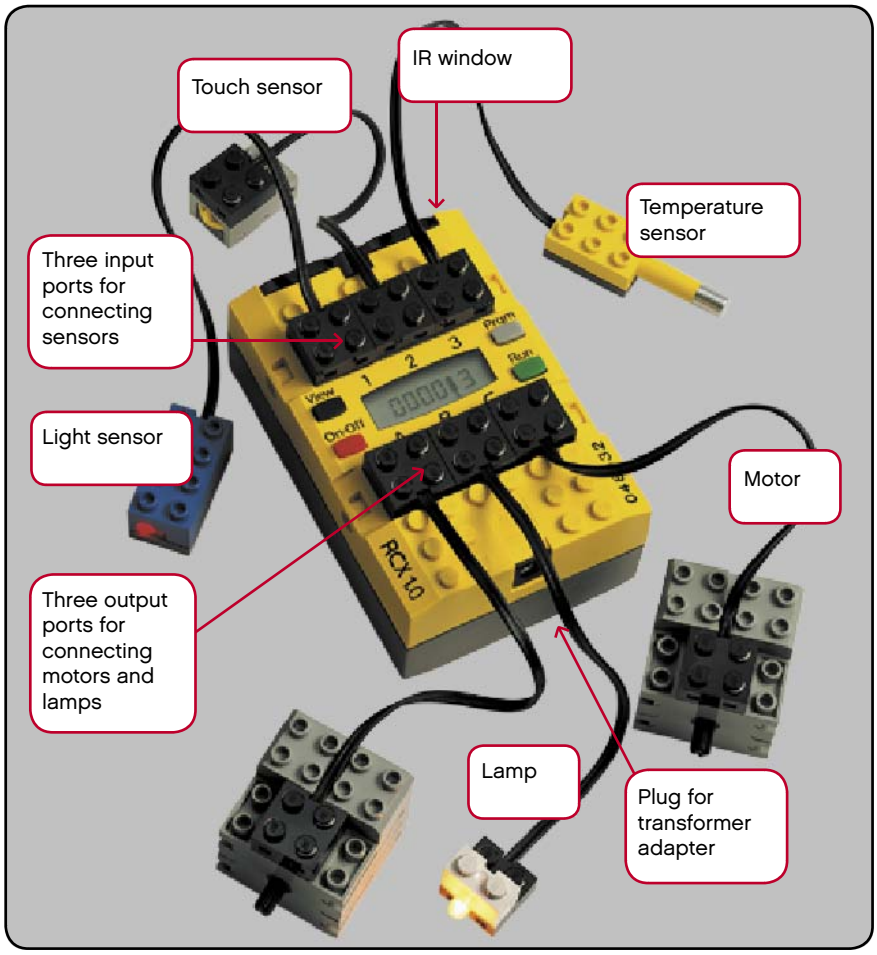
LEGO® MINDSTORMS™ for Schools uses the ROBOLAB software to write programs. The ROBOLAB software runs on both PCs and MACs. LEGO MINDSTORMS for Schools includes an RCX—a programmable LEGO brick. The RCX is a microcomputer with three output ports A, B and C for connecting motors and lamps, and three input ports 1, 2 and 3 for connecting sensors. ROBOLAB programs are downloaded to the RCX via an Infrared (IR) Tower. The IR Tower is available with a serial connection (COM port) or a USB connection (for 2.5 or higher versions only).



Serial (COM port) Infrared Tower, requires a 9 volt battery

USB Infrared Tower

Installing ROBOLAB software and preparing the RCX brick and IR Tower

1. Insert the ROBOLAB CD-ROM in your CD drive and start the program. Follow the installation instructions. The installation will take up to 20 minutes. DO NOT connect the IR Tower until told to.

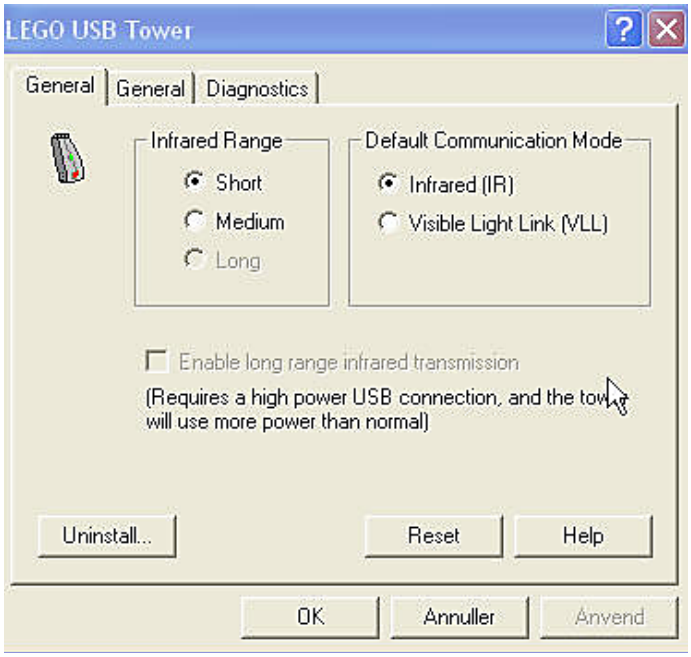
2. While waiting for the installation to finish you should insert 6 AA batteries in your RCX. Remove the grey cover and place them according to indicators at the bottom of the RCX. You can also use rechargeable batteries or a 9–12 volt LEGO transformer (product number 9833).

3. When the software has been installed successfully, you should un-tick the box 'Launch ROBOLAB', so that you do NOT start ROBOLAB yet.

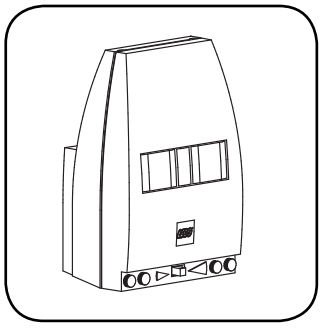
4. Now you must connect your IR Tower to your computer. Make sure ROBOLAB is shutdown before connecting the USB IR Tower. ROBOLAB will NOT detect the USB IR Tower if you connect it while ROBOLAB is running. If you have a USB IR Tower simply connect it to a USB port.

5. If you have a serial IR Tower you must first insert a 9-volt battery before connecting it to a serial port (COM port).

NOTE: Infrared communication between the IR Tower and the RCX reaches up to 10 meters. However, communication can be interrupted if there are several RCX bricks within reach of one IR Tower. Therefore the IR Tower should always be set to short range when working with more than one RCX in a classroom.



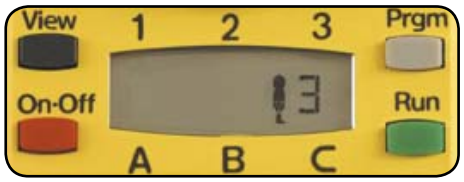
For the USB Tower adjust the setting in the Windows Control Panel. Click the Start icon on your desktop, open Control Panel, select the LEGO USB Tower icon and set the Infrared Range to short.



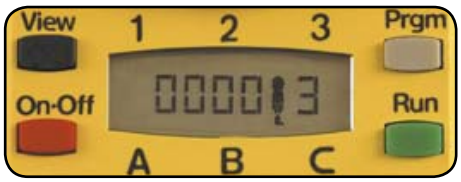
To select the short range on the serial IR Tower move the switch to the left at the front bottom of the .

Installing Firmware

Firmware is the software you need to download to the RCX before using ROBOLAB to write programs. You can always check if the firmware is installed on your RCX by turning it on. If the display shows 00.00 firmware is installed. If the first four digits are missing there is no firmware.



Display showing no firmware installed



RCX with firmware installed

To install firmware:
1. Start ROBOLAB. Select Start at the rear left hand corner of your screen. Scroll up to programs and select ROBOLAB.
2. Select Administrator.
3. Turn on the RCX by pressing the red On-Off button.
4. Place the RCX in front of the IR Tower (the IR window of the RCX must face the IR Tower)
5. Select download firmware. It takes about 4 minutes.
6. Select the 'Back' button when the firmware has been successfully installed.
7. Your RCX is now ready for programming in ROBOLAB.

NOTE: If you remove the batteries from the RCX the firmware will be lost and you will have to download it again. To keep the firmware when changing batteries you must first turn off the RCX, then change the batteries within approximately one minute. If you change the batteries one at a time you will have one minute for each battery.

Trouble Shooting—Firmware

If the firmware has suddenly been lost it may be lost on the RCX because two or more RCX bricks were in reach of the same IR Tower when the program was downloading. Turn off the RCX bricks that you are not downloading to, or keep them out of reach of the IR Tower. Make it a standard procedure to turn off an RCX that you are not using. This also saves battery life—even though the RCX turns off automatically after 15 minutes.

Trouble Shooting—Infrared Communication

Strong light may interrupt the infrared communication. Cover the IR Tower and the RCX brick
High temperature may cause interruption. Computer labs are often very warm, place the IR Tower on the floor.
Mirrors and reflecting surfaces may cause interruption, point the IR Tower in another direction, but still facing the RCX IR window.
Serial IR Tower is not working. Check that the battery is in place.
If download is still failing you can place the IR Tower and RCX under the green plastic storage box or a cardboard box. This should efficiently eliminate interruptions.
If the computer doesn't detect the IR Tower you can use an automatic detection function. Access via the front page of ROBOLAB. Select Administrator, select Select COM Port then choose Auto Detect.

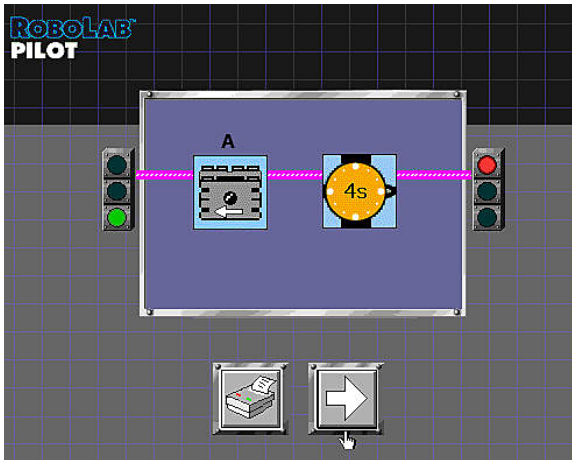
PILOT Course Levels 1–4
(Estimated time needed 1–2 hours)

Pilot Level 1

Turning a motor on or off

1. Connect a motor to port A on your RCX and turn the RCX on by pressing the red On-Off button. If you connect a wheel to the motor you will be able to see which direction the motor is programmed to run.

2. Start ROBOLAB, select Programmer and double-click on Pilot 1. A default program will appear on your screen. The motor icon offers you a left (clockwise) or right (counter clockwise) option.



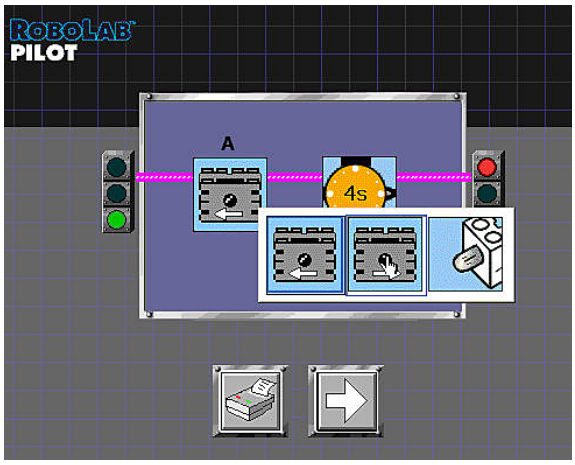
3. Place your RCX in front of the IR Tower. Make sure the RCX is turned on. NOTE that the RCX automatically turns off after 15 minutes.

4. Select the white arrow button, which is the download button. A new box appears on your screen indicating that download is proceeding.

5. Press the green Run button on your RCX.
a. Is the motor running? If not—have you connected the wire to port A?
b. Is the wheel turning counter clockwise? If not—turn the wire connector on port A 180 degrees and press the green Run button again.

6. Now modify the program so that the wheel turns counter clockwise for four seconds.
a. Select the motor icon on the screen and change direction.
b. Then select the time icon to change the time setting.

7. Download your new program by selecting the white download arrow and press the green Run button on the RCX.



Test Your Skills—Stop the motor on time

1. Build a car driven by one motor. See building instructions on page 25. Follow steps 1 to 4.

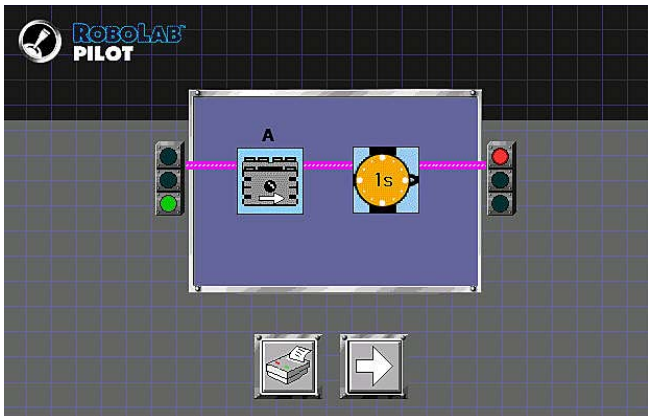
2. Program the car to move forward for one second

3. Place a measuring tape on the floor and test how far the car travels in one second. Repeat the test three times to calculate an average distance.

4. Place a LEGO figure or other object on the floor next to the measuring tape at a distance equivalent to that covered in one second.

5. See if the car travels the correct distance without knocking the figure over.

6. Repeat points 3,4 and 5 changing the time to 2, 4 and 6 seconds and calculate the distance to be covered each time.



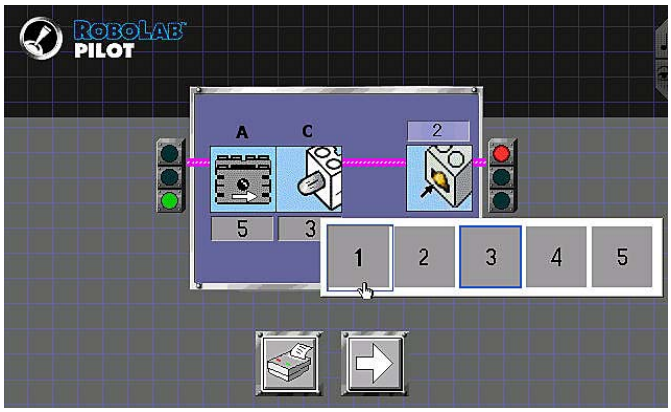
NOTE: This is a good classroom activity to try with several groups of children, each performing the same task and comparing results. Let each group make a graph with time and distance and plot in their results.

Pilot Level 2

Introducing lamp, touch sensor, and setting power levels

At this level you can work with output ports A and C, set the power level and use a touch sensor.

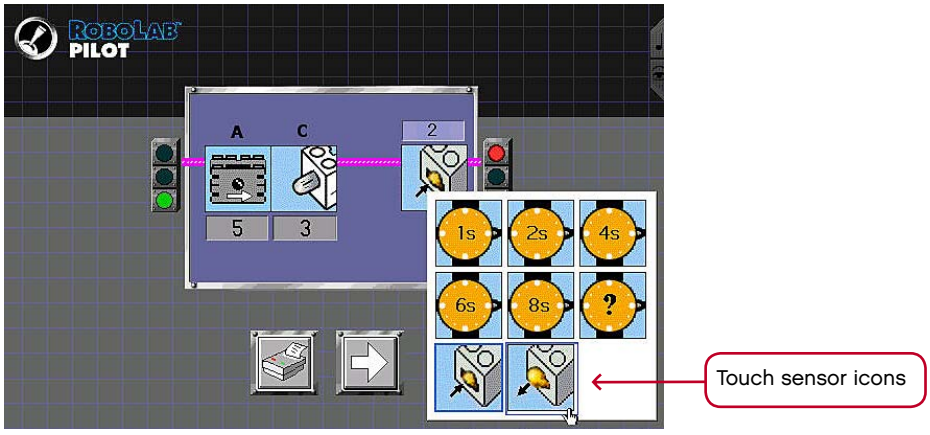
1. See building instructions. Follow step 4a on page 28—attaching a lamp and touch sensor.
2. If you are still in Pilot level 1 select Back and then select Pilot level 2.
3. The motor icon must be set to run clockwise (pointing right) at full speed (5)
4. The lamp should be set to the lowest power level (1)
5. The touch sensor must be set to port 2. Select the icon indicating that the sensor is pressed in. (See program illustrated below)
6. For this activity you will hold the touch sensor in your hand and press when you want the vehicle to stop.
7. Download and run the program



Test Your Skills—Vary power levels and change directions

Try making your own combinations by varying power levels for the lamp and selecting different directions for the motor.

Try the other touch sensor icon, which reacts when the touch sensor is released. This works, for example, when a vehicle drives over a raised surface where the touch sensor is pushed in—then reaches a lowered surface where the touch sensor is automatically released.

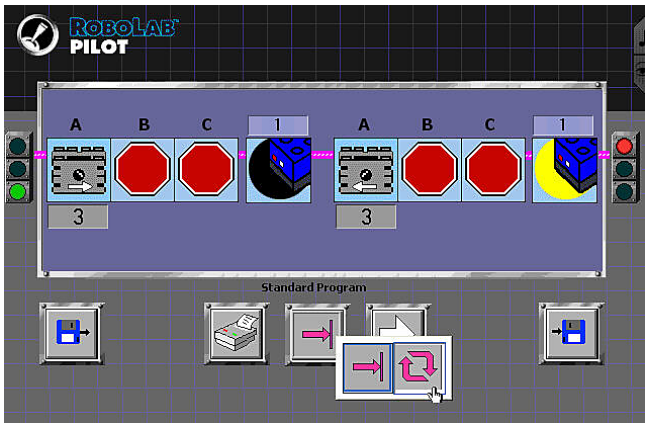


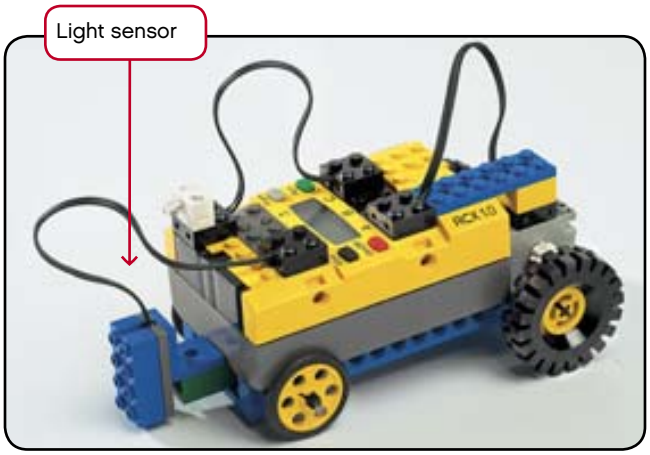
Pilot Level 3

Programming with two steps, introducing light sensor and loops

At this level you can work with all three outputs and use the light sensor. Furthermore you now have two programming steps. You will need to use the red stop sign to block a port that is not in use.

1. See building instructions. Follow instructions for 4b on page 29—attaching a light sensor and a lamp.
2. Select Pilot level 3.
3. Program the following:

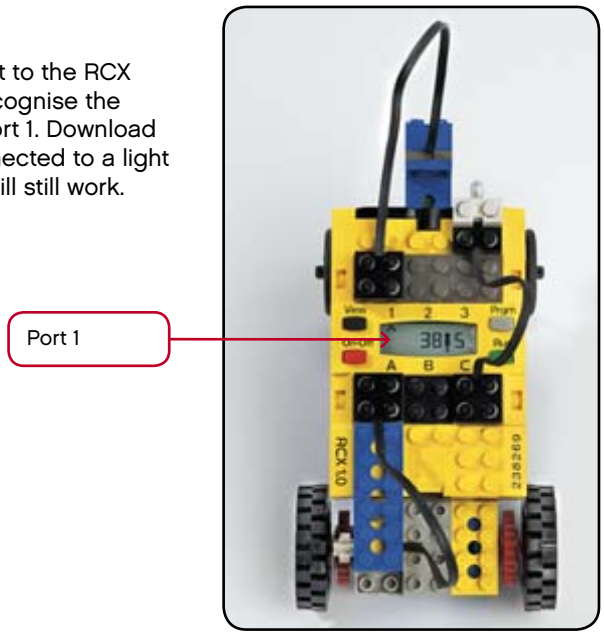




4. Download the program to the RCX.
5. Press the black view button on the RCX. Continue pressing until the arrow in the display points to port 1.
6. Hold the car in your hand. Point the sensor at a light surface (at a distance of about 5mm) and press Run. Then move around the room holding the sensor up to different surfaces. As soon as the light sensor records a darker surface (5% less light than previously) the motor will change direction. Since you have programmed it with a loop, it will do that continuously until you press the green button again.

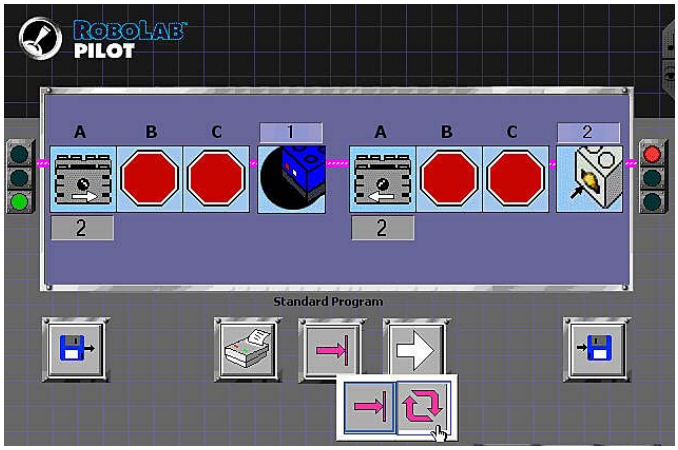
Trouble Shooting – Light Sensor

If there is no signal (red light) on the light sensor when you connect it to the RCX this means that ports 1, 2 and 3 on the RCX do NOT automatically recognise the sensors. You must write a program where the light sensor is set to port 1. Download this to the RCX and run the program. Now port 1 knows that it is connected to a light sensor. You can turn the RCX off and on again and the light sensor will still work.



Test Your Skills—Program a car to respond to light readings

1. Write a program in Pilot level 3 that makes the car move forward until the light sensor meets a darker reflection (such as the edge of the table). Then tell the car to move backward until you stop it by pressing a touch sensor. We recommend that you program the car to move slowly. Set the motor power level to 2 or 3.
2. You could also program the lamp to be on when moving forward and off when moving backwards.
3. To repeat this program you need to activate loop mode. Select the pink arrow and select the loop icon.
See illustration below.

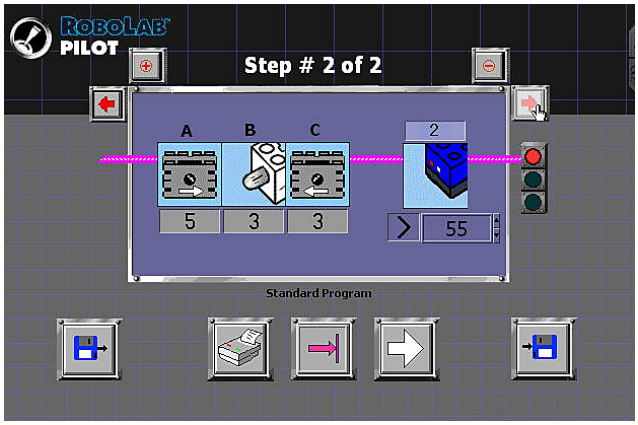


Pilot Level 4

Programming with multiple steps

At this level you can add extra steps to the process to make the program more complex.

When you open Pilot level 4 you will find a sample program with two steps. To avoid confusion when making your first program you should delete step 2. Select the red arrow as shown below, then select '-' and delete. To create extra steps select the '+' button. To scroll through the steps select the red arrows.

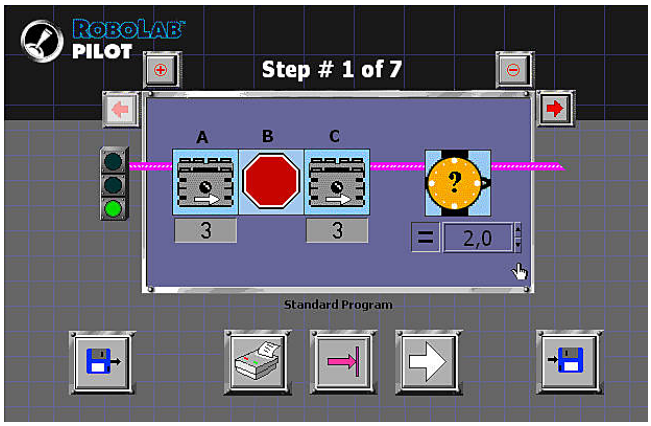


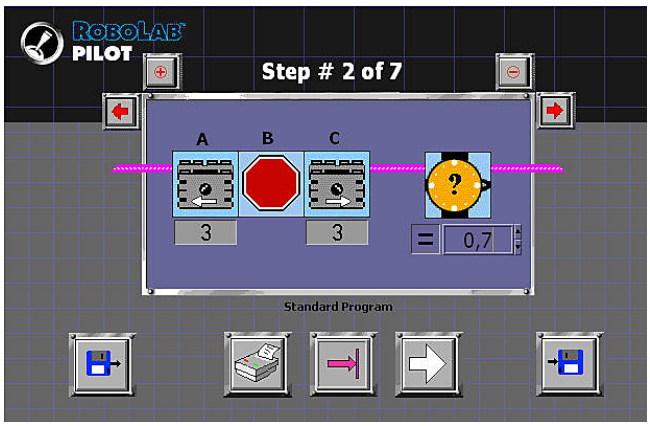
Test Your Skills—Program a car to drive in a rectangle

1. Use the LEGO model illustrated in the building instructions of your RoboTechnology Sets 9785/86 (pages 17–24) or Team Challenge Sets 9793/94 (pages 4–21 and page 24). See the illustrated overview of elements provided in each kit.

2. Program your vehicle to drive in a rectangle. You will need to program seven steps. Step one, program both motors so that the vehicle runs forward. Step two, turn 90 degrees. To make the model turn 90 degrees you will need to ask one motor to drive forward and the other to drive backward.
Step three, move forward. Step four, turn 90 degrees. Step five, move forward. Step six, turn 90 degrees. Step seven, move forward and stop. Download and run your program.

NOTE: After finishing Step 2 you should download and test the program to determine how long it takes for the model to turn 90 degrees. Note that the speed will vary depending on the age of your batteries. Different surface types also affect turning speeds; select a smooth surface for best performance. Here is a possible solution for steps 1 and 2.





Congratulations!

You have now completed the first part of your Quick Start Guide to programming in LEGO MINDSTORMS for Schools.

For more ideas about how to use these skills in the classroom see the activity packs for the RoboTechnology or Team Challenge Sets, or visit **www.LEGO.com/education/MINDSTORMS** for information about additional sets.

INVENTOR Course Levels 1–4
(Estimated time needed 2–3 hours)

You are now entering a new world of programming, where the principles learned at Pilot level are relevant, but where many new features will be introduced. Programming at this level is far more challenging and complex. We hope that this introduction will give you the confidence to get started. Programming takes place by dragging icons from a number of function panels and dropping them into the programming window. Each Inventor Level offers an increasing number of programming options.

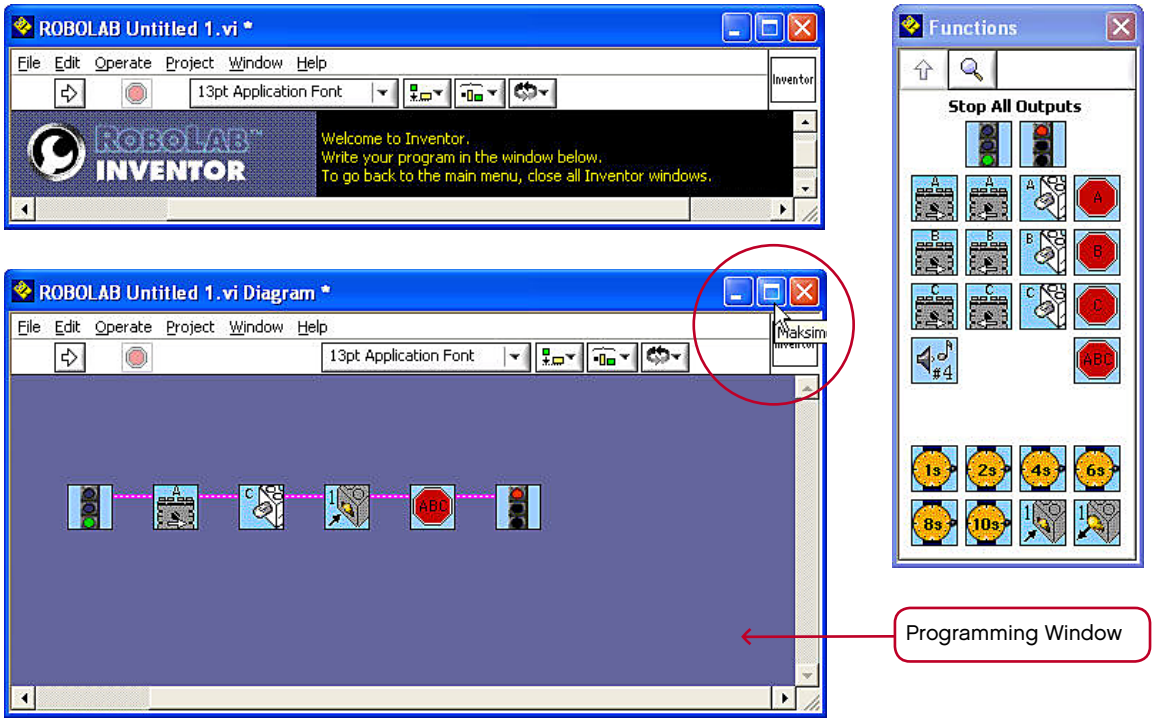
Inventor Level 1

Get to know the basic icons and how to string them together

Use the LEGO model illustrated in the building instructions of your RoboTechnology Sets 9785/86 (pages 17–24) or Team Challenge Sets 9793/94 (pages 4–21 and page 24). See the illustrated overview of elements provided in each kit.

1. Start ROBOLAB, select Programmer. Double click Inventor level 1.

2. You will see a default program on the screen. Maximise the programming window.


ROBOLAB Untitled 1.vi *
File Edit Operate Project Window Help
13pt Application Font
ROBOLAB™ INVENTOR
Welcome to Inventor.
Write your program in the window below.
To go back to the main menu, close all Inventor windows.
ROBOLAB Untitled 1.vi Diagram *
File Edit Operate Project Window Help
13pt Application Font
Functions
Stop All Outputs
Programming Window

3. Click your mouse on the programming window – it will either show you a black arrow, a white hand, a cable reel or a text editing function. You can change the function of the mouse by pressing the Tab button on your keyboard.

Tools Palette

NOTE: You can also access these functions by selecting 'Window' in the top menu and scrolling down to 'Show Tools Palette'.

4. Select the black arrow function and mark the icon after the green traffic light. Click the left button on your mouse and press delete on your keyboard.

5. Continue to select each icon and delete until you only have the green and red traffic lights left. Note that you can also delete several icons by dragging the mouse across a selection and then pressing delete. Click and drag your red lights further to the right side of the screen.

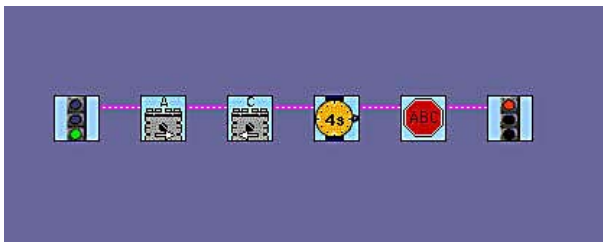
6. You now have space to select your own string of icons and practice linking them together.

7. You can copy the suggested program below, or select your own. To link each icon press the Tab bar until your mouse becomes a cable reel. Click on the right hand corner of one icon until it reads 'end' and then click on the left hand corner of the icon you wish to connect it to until it reads 'begin' and then release. A pink connecting line should appear between the icons. You have to continue linking in this way until the line of icons is joined up.

8. If your connecting lines are black and white, this indicates that they are not active. Go into Edit on the menu bar and select 'Remove broken wires' or press Control 'b', which is a shortcut. Then try to connect again using the cable reel.

9. When all connecting lines are linked the white download arrow will become active and you can download the program to the RCX.

10. Copy the string illustrated below and download it to your LEGO vehicle. Note that in Inventor level you need to insert Stop icons in order for the program to stop the previous instruction.

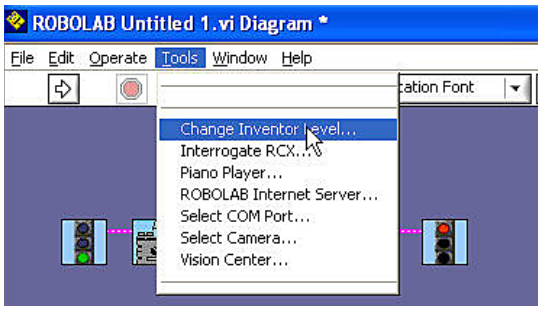


The program will turn motor A and C on in different directions, wait for 4 seconds and then turn off all outputs before stopping. Your vehicle will run in circles for 4 seconds.

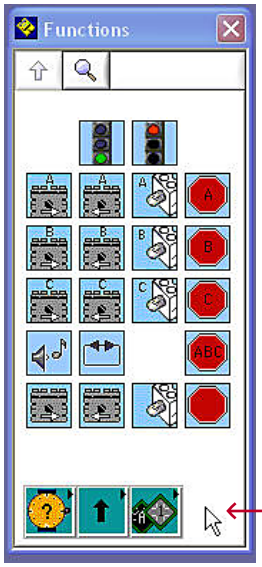
Inventor Level 2

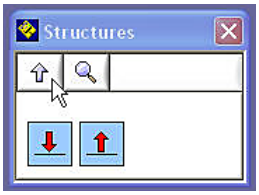
Introducing modifiers, flip direction, jump & land and random time functions.

At the top menu select Tools or Project (depending on version) and scroll down to Change Inventor Level. Choose Inventor level 2.



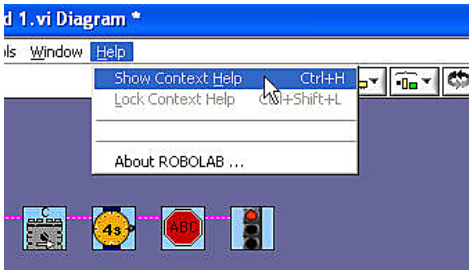
Your programming options now expand to include 3 new sub-menus called Wait For, Structures and Modifiers. To return to the main functions palette select the white vertical arrow in the sub-menu.

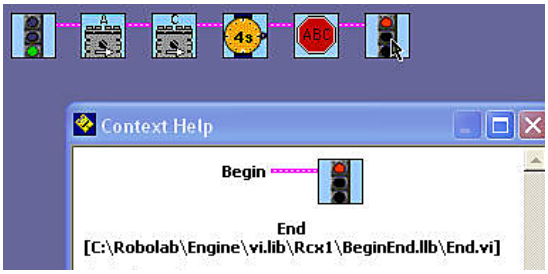




Wait For, Structures and Modifiers

Select the Help menu and scroll down to Show Context Help to find out what the icons do. You can also place the icons on your screen, move the mouse over a chosen icon and the information will automatically appear.





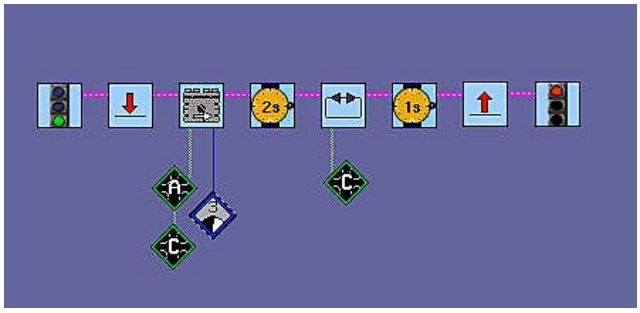
Use your two motored vehicle as for Inventor level 1.
1. Delete all icons between the start and stop lights. Start by dragging the red traffic light icon further to the right so that you have enough space on the screen to build your program.
2. Copy the program string shown below. Note that the motor icon should not be predetermined to a specific port, and that the flip direction icon is situated below the motor icons in the functions palette. You now need to use new programming icons, which tell the program to jump and land. Jumping and Landing is a way to loop the program as seen in Pilot levels. Looping means repeating the program continuously. It is a good idea to begin saving the programs that you create. See top menu under File.

Motor not predetermined

Flip Direction

Jump and Land

3. Download the program and run it. NOTE: Modifiers also need stringing together. Motor modifiers must be connected to the rear left and power levels to the rear right.



The program turns motor A and C on at power level 3, waits for 2 seconds, then flips the direction of motor C, waits for 1 second and jumps back to the red land arrow and repeats the program. Your car should repeatedly move forward for 2 seconds and turn for 1 second.

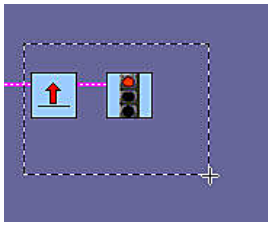
Introducing Play Sound and Random Time functions

1. Use your two motored vehicle as for Inventor level 1 and the same program as above.
2. You will now make the vehicle “wait for” random time instead of 2 and 1 seconds. (See program under point 6 on page 17)

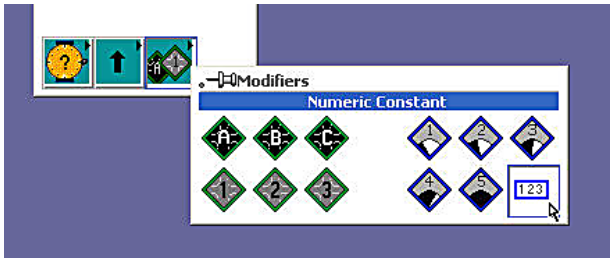
Random Time

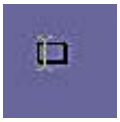
3. Delete the two Wait For icons and insert the random time icon. Remove bad wires (illustrated as black and white as opposed to pink) using Ctrl b and insert new wires using the cable reel via the Tab button. (If you use ROBOLAB 2.5 right click the icon and choose replace). The next icon you choose will be inserted and connected automatically.

4. Select the Jump icon and the red traffic light icon by dragging the mouse across them. Move them to the right, now there is space for the Play Sound icon. Insert it after deleting the wire between the Random Time and the Jump Icon. (If you use ROBOLAB 2.5 right click the wire and select Insert)



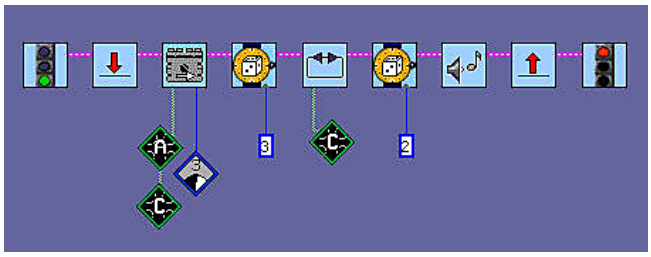
5. Now insert 3 and 2 seconds as the maximum time (default is 5 seconds) using a numeric constant, which is located in the Modifiers palette. As soon as you have dragged the icon into the programming window you can write its value. Alternatively you can use the Tab button to access the Write Icon and then write the value in the numeric constant.





Write Icon

6. Download the program illustrated here and try it out on the floor.



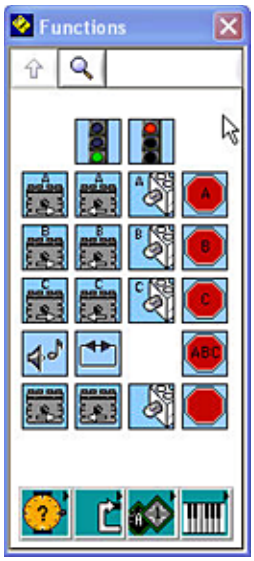
The program turns motor A and C on at power level 3 and waits for random time (between 0 and 3 seconds), then it flips the direction of motor C and waits for random time (between 0 and 2 seconds) plays a sound and jumps back to the red land arrow and repeats the program. Your car will move forward for 0–3 seconds, turn for 0–2 seconds and play a sound repeatedly. The sound is the same as that which the RCX makes when it has downloaded a program.

Inventor Level 3

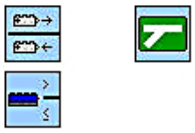
Introducing music, task split, loop and fork merge options

At the top menu select Tools or Project (depending on version) and scroll down to Change Inventor Level. Select Inventor level 3.

Again the Functions palette expands. One new sub-menu called Music is now available and the Structures sub-menu is expanded with three new features; Fork Merge, Loop and Task Split. You can also choose random power level for outputs in the Modifiers sub-menu. The small black arrow at the top right corner of the Music icon indicates that the menu expands further.



Music Icon



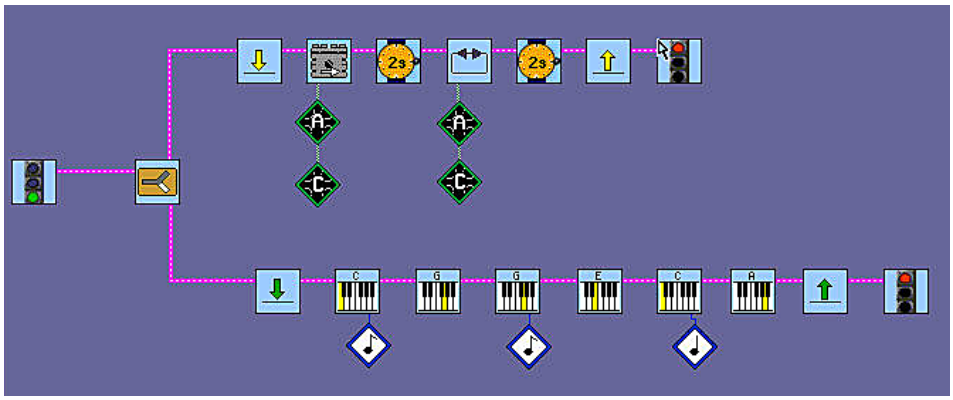
Fork Merge Icons

Wait For, Structures (including Fork Merge), Modifiers and Music

Remember you can use the Help menu. Scroll down to Show Context Help to find out what the Fork Merge Icons do. You can place the icons onto your screen and move the mouse over a chosen icon and the information will automatically appear.

Introducing the task split command

1. Use your two motored vehicle as for Inventor level 1.
2. Delete the program on the screen and copy the program string below. This program asks the RCX to do two different tasks at the same time.
3. Download the program illustrated below and try it out on the floor.

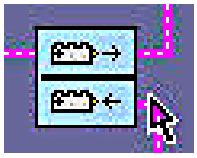


At the upper string motors A and C turn clockwise, wait for two seconds, flip direction, wait for another two seconds and then jump back to the yellow arrow and repeat the task. The lower string continues to play six notes. The program must be stopped by pressing the Run button. The vehicle will drive forward and backward while playing a melody.

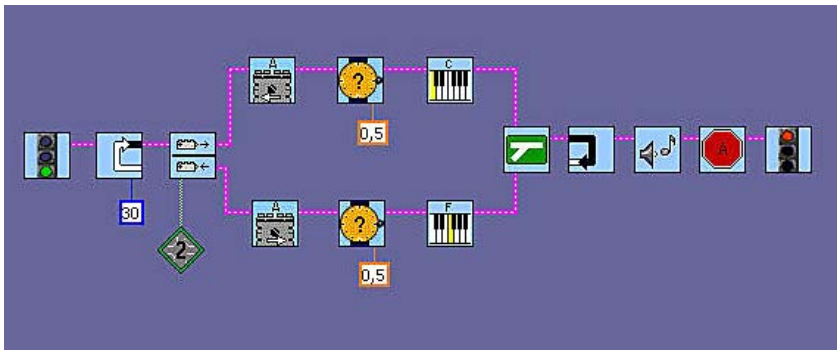
Introducing touch sensor fork and merge and a specified number of loops

1. Use your two motored vehicle as in Inventor level 1. Attach a touch sensor, making sure it is correctly connected to Port 2 with a long wire.
2. Delete the program on the screen and copy the program string below. You will need the Touch Sensor Fork icon to tell the vehicle how to distinguish between pressed and released.

Touch Sensor Fork

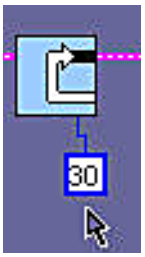


3. Download and run the program illustrated here. Try estimating how long the program will last.



The loop will be repeated 30 times. The Touch Sensor Fork determines the direction of the motor. If the yellow touch button is released (upper fork) Motor A and C will turn clockwise (backwards arrow), then the program waits for 0,5 of *a second before playing a C-note and returns to the Touch Sensor Fork icon. The same will happen again until the touch sensor is pressed in. The string below is now activated—motors A and C will be turned on counter clockwise (forward arrow), wait for* 0,5 of *a second; play an F-note and return to the Touch Sensor Fork. You can activate or release the touch sensor as often as you wish, to observe how it changes direction After the upper or lower strings have been repeated 30 times the RCX will play a sound indicating that the program is complete.*

Loop Icon set at 30



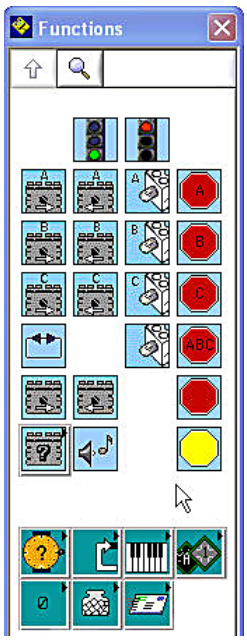
Inventor Level 4

Introducing Containers

At the top menu select Tools or Project (depending on version) and scroll down to Change Inventor Level. Choose Inventor level 4.

This level gives you access to all the ROBOLAB programming icons and lets you make very advanced and complex programs. You can explore the possibilities by using the Context Help menu or see the Using ROBOLAB guide, which you can purchase along with the software.

Three new sub-menus called Reset, Containers, and RCX communications appear. (Please note that there are an additional 8 sub-menus in ROBOLAB 2.5.)



Container Icons

Wait For, Structures, Music, Modifiers and Container Icons

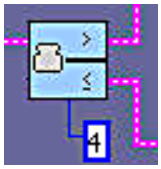
Introducing Container Commands

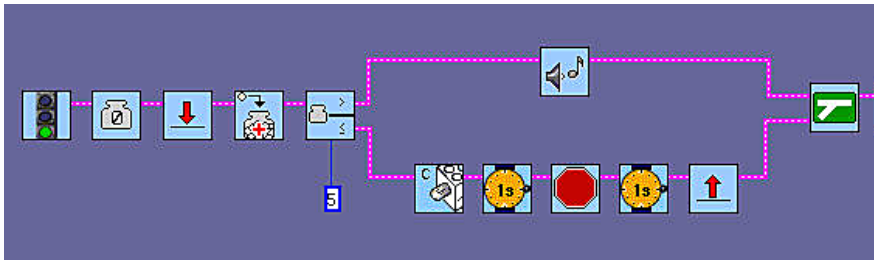
A Container is an icon that stores a value and tells the program when to send that value to another programming icon. Within the Container the value can be multiplied, divided or subtracted.

1. Use your two motored vehicle. Make sure the lamp is connected to output port B. You will not be using the motor or touch sensor.

2. Delete the program on your screen and copy the string below. For this challenge you will need the Container Fork icon to tell the robot how to distinguish between the value stored in the container.

Container Fork Icon



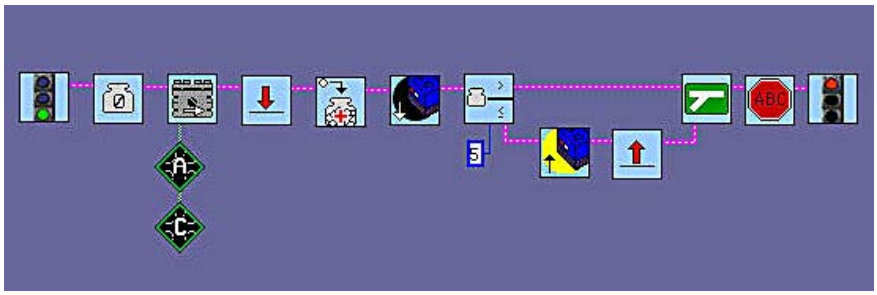


First the program must make sure that the container is empty—this is just a precaution against readings that may still exist in the RCX from previous activities. The Add to Container adds a value of one to the Container Fork. The Container Fork is set to count the light being turned on five times. So long as the value is below five, the lower string is chosen.

The lower string turns on the lamp, waits for one second, turns off the lamp and waits for one second again. The red Jump Arrow, returns the program to the red land arrow.
This is repeated until the container has added a value of one, five times—after which it adds a final value that tells the Container Fork to choose the upper string, a sound is played and the program ends.

Introducing a different way to use the container commands, combined with light sensor

1. Use your two motored vehicle. Make sure the light sensor is connected to Port 1. On a long strip of paper draw 10 parallel thick, dark lines with an identical distance of 5 to 10 cm.
2. Delete the program on the screen and copy the program string below. For this challenge you will need the Container Fork command to tell the robot to react to the value of the container.
3. Download and Run the program illustrated here.



First make sure that the container is empty. The motor is turned on and as soon as the light sensor reads a lower light value a value of one is added to the Container Fork. When the sensor reads a higher light value the jump arrow returns the program to the land arrow. This is repeated five times, after which the container adds a final value to the Container Fork, which tells it to run the upper string and complete the program.

Ideas for practising your skills

- Create a robotic puppy dog with an appealing look and programmed behaviours that include movements and sounds
- Roaches do not like light. Build and program a bug that turns and runs away when light shines on it.
- Create a ceiling fan
- Create a garage door that opens automatically
- Create an automatic vacuum cleaner that turns when it hits an object, or a lawn mower which remains on the grass using a light sensor and black tape to define the edge
- Construct a labyrinth and get your robot to follow the route (or get out of a maze)
- Construct a bumper car that changes direction every time it hits an object
- Compose your own melody and dance routine

Congratulations!

You have now completed the second part of the Quick Start Guide to programming in LEGO MINDSTORMS for Schools. For more ideas about how to use these skills in the classroom see the activity packs for the RoboTechnology or Team Challenge Sets, or visit **www.LEGO.com/education/MINDSTORMS** for information about additional sets.

Investigator

A general introduction

This section is for information only and does not include training schedules.

Investigator extends the use of the RCX and ROBOLAB to include the creation of experiments that use programming, data logging, computation tools, and documentation. The programming tools in Investigator are the same as those found in Pilot and Inventor Levels with additional commands for data logging.

Students program their RCX to collect information. After running their program, they then upload the collected data, via the Infrared Tower, to ROBOLAB for further analysis and comparison.

Students can use a Journal tool to:
- Record hypotheses
- Record findings
- Add charts and data to support conclusions
- Publish results for an on-screen presentation

Programming in Investigator

The Program Area of Investigator provides five programming levels. The first three levels are Pilot Templates. Levels 4 and 5 utilise the flexibility of Inventor Programming.

The type of data captured depends on the sensor selected in the program.
Options include:
Touch Sensor
Light Sensor
Temperature Sensor
Angle Sensor
Rotation Sensor
Generic Sensor for non-LEGO sensors

Navigator

A Navigator tool is provided, providing access to the following functions: (pictured clockwise)
Traffic Lights—this brings you into the programming area
The White Arrow—this brings you to the upload area, where you upload the data you have gathered
The Buckets—this brings you to a view and compare area, for all the data you have gathered
The Calculator—this brings you to a computing tool where you use arithmetic calculations to compute your data

Capturing Data

The upload area allows you to upload data from the RCX to the computer and view it on a graph.

Data sets are uploaded from the RCX to ROBOLAB in the upload window. All data sets are plotted on their own page in the upload area. If data from more than one sensor is acquired when the RCX program is run, upload opens a new page for each data set. A window tells you how many data sets were uploaded. All pages are listed in a Page Control Area of the Navigator

Once the data is uploaded, it appears in a plot in the upload area. The plot is labelled with the sensor value on the y-axis and time on the x-axis. The data display can be changed by selecting a new plot type.

Data sets plotted on the upload page are stored in bins. More than one data set can be stored in the same bin. Bins are designated by colour. Selecting different bin colours is useful to separate the data from different sensors. You can also name the bins and change their colour.

You have two options when capturing data:
1. Download the program to the RCX and store it until you are ready to run and capture data.
2. You can select a Direct Mode, which downloads the program to the RCX and begins capturing data and showing it on the computer immediately.

Ideas for practicing your skills in Investigator

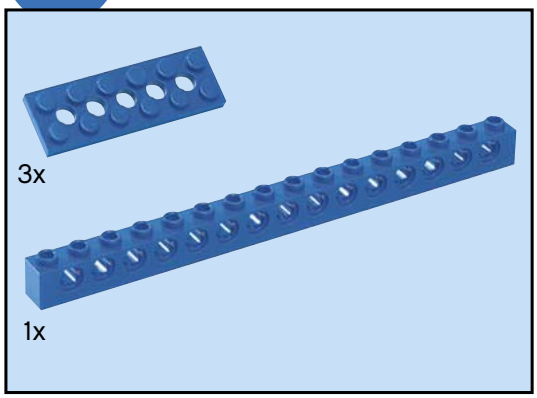
Using different sensors for data logging, there are unlimited ways to use Investigator.
Here are a few suggestions:

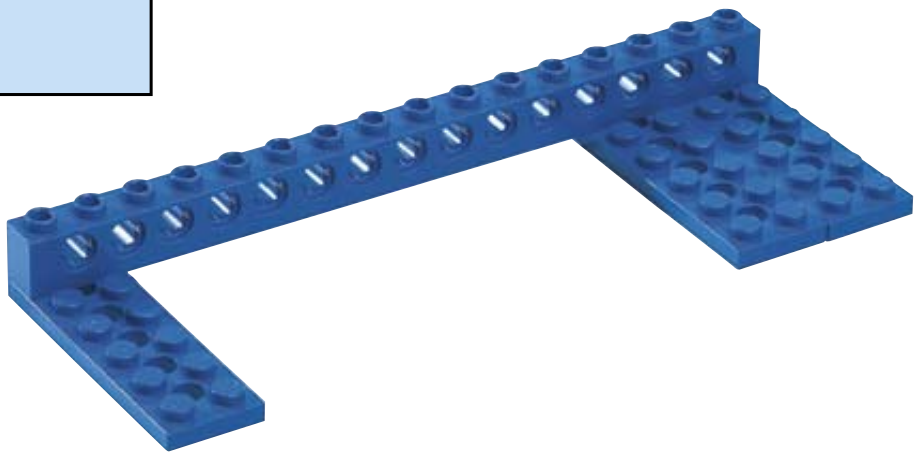
- You want to find out the light and temperature conditions in a cave, but it is too dangerous to go in yourself. Send in an RCX rover instead
- Build and program a device to cool down your drink as fast as possible. Include a temperature sensor to measure how long it takes to cool
- What is the speed of your car? Use the light sensor mounted on an RCX car to track the distance traveled
- Construct a smart golf club. It should keep track of the strokes you've played by using a touch sensor to record each time you hit the ball.
- Create a Weather Station (data logging temperature, humidity, downfall)
- Use the rotation sensor for measuring the speed of a non motor vehicle running down an inclined plane

This guide is intended as an appetiser for newcomers to LEGO® MINDSTORMS™ for Schools products. If you want to explore the unlimited possibilities in ROBOLAB see the Using ROBOLAB guide, which is provided in PDF format together with ROBOLAB software.

You can also find inspiration on the LEGO Educational Division website at: **www.LEGO.com/education**

1





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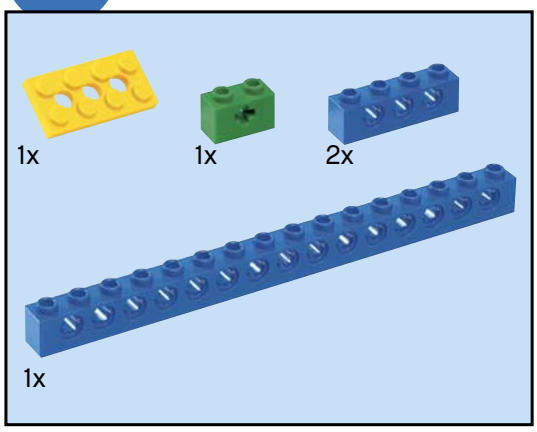

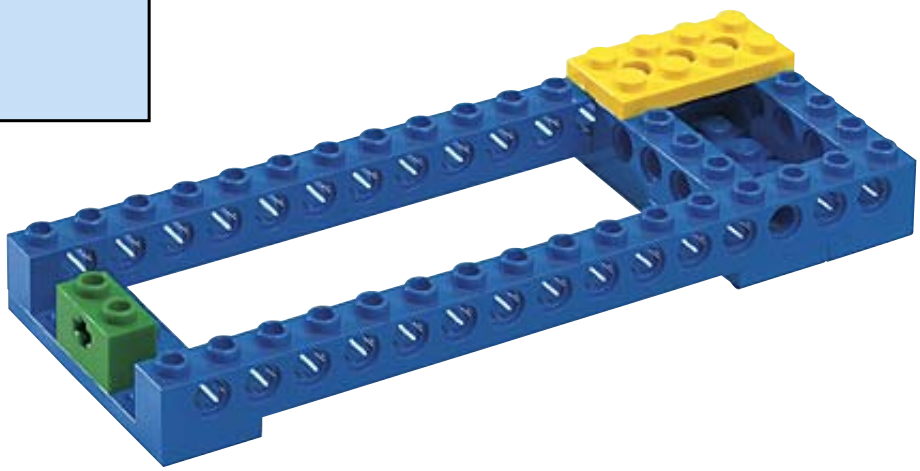

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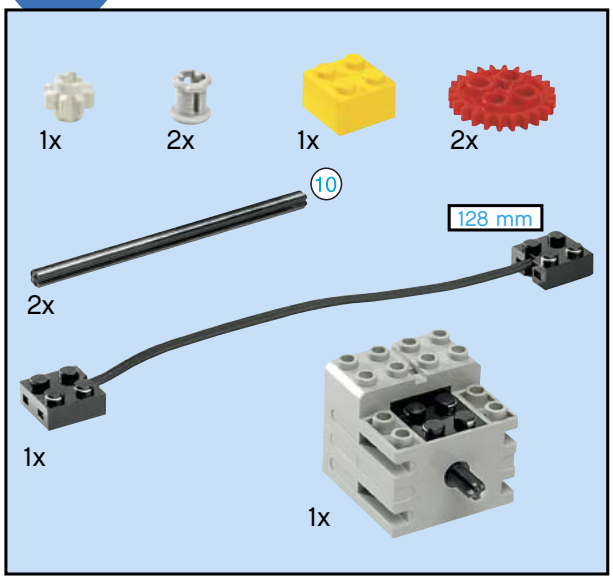

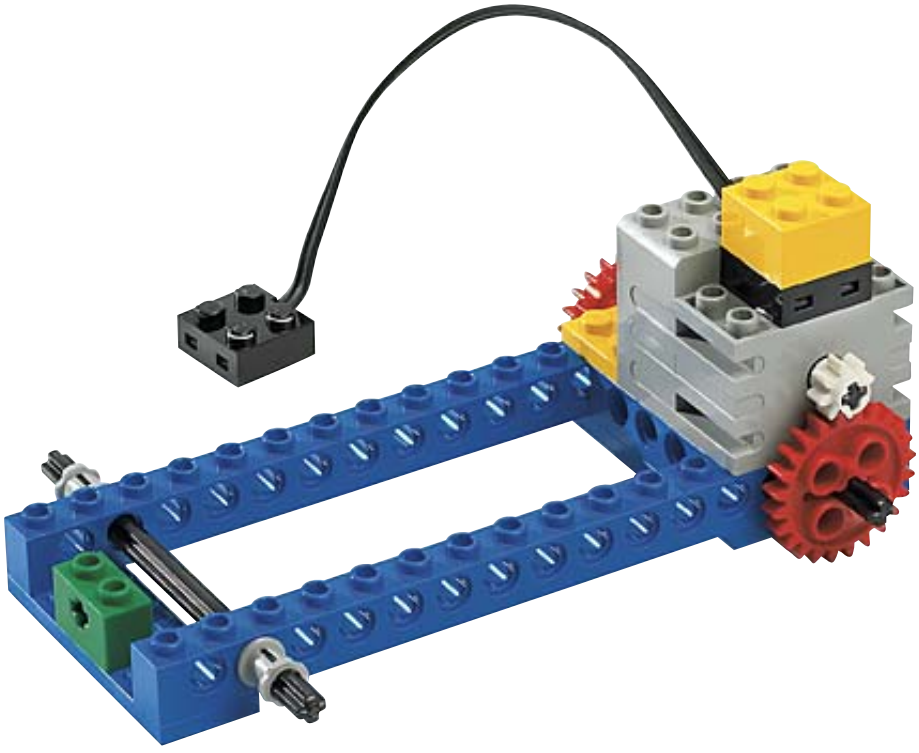

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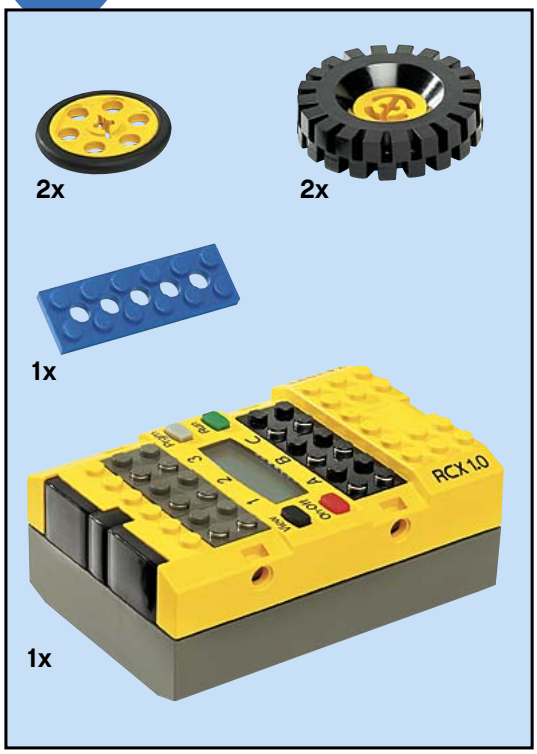
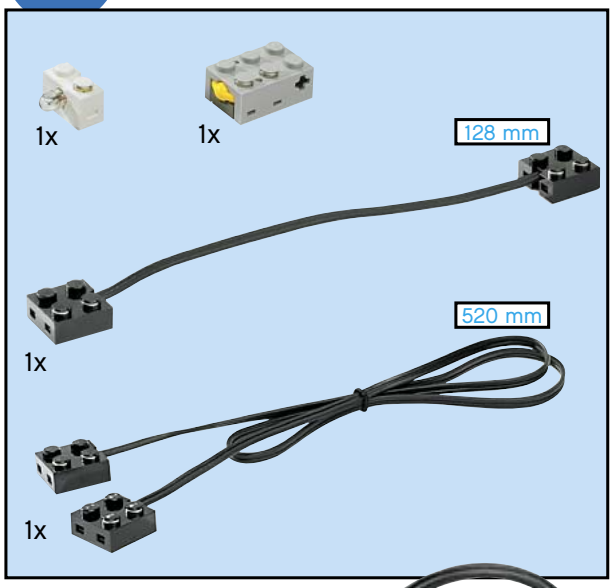


4a



4b